PRELIMINARY RESEARCH PROPOSAL
SUBMITTED TO THE U.S. ARMY CORPS OF ENGINEERS UNDER THE ANADROMOUS FISH EVALUATION PROGRAM
2007 PROJECT YEAR

I. BASIC INFORMATION

A. TITLE OF PROJECT

ESTIMATION OF THE DISTRIBUTION OF RIVER-RUN JUNVEILE MIGRANTS AT TURBINE WICKET GATE ENTRY

B. PROJECT LEADERS

Thomas J. Carlson, Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99352, Tel: 503/417-7562, Email: Thomas.Carlson@pnl.gov

Gene R. Ploskey, Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99352, Tel: 509/427-9500, Email: Gene.Ploskey@pnl.gov

Robert A. Davidson, Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180, Tel: 601/634-3052, Email: Robert.A.Davidson@erdc.usace.army.mil

C. STUDY CODES

TSP-06-01; Objective 4

D. ANTICIPATED DURATION

October 2006 - September 2008

E. DATE OF SUBMISSION

September 2006

II. PROJECT SUMMARY

A. GOALS

1. Estimate the vertical distribution of spring and summer juvenile migrants passing through the plane of the downstream bulkhead slot and entering the wicket gates of a turbine during normal operations at a dam to be selected in consultation with the Turbine Survival Program technical team.
2. Evaluate the use of turbine physical models to estimate the entry distribution of juvenile fish to a turbine's wicket gates at prototype scale given knowledge of the distribution of unguided juvenile fish in the plane of the downstream bulkhead gate slot of a prototype turbine.

B. OBJECTIVES

1. In collaboration with the TSP technical team identify a project at which a turbine is or will be dewatered and available for installation of instrumentation and for which a physical turbine model exists.
2. Determine the distribution of unguided juvenile migrants passing through the plane of the downstream bulkhead slot and at entry to the turbine's wicket gates.
3. Determine the distribution of beads at entry to a physical turbine model's wicket gates following release in a pattern that simulates the distribution of unguided juvenile migrants observed in objective 2.
4. Test the hypothesis that the distribution of unguided juvenile migrants upon entry to the prototype turbine's wicket gates is the same as that observed for beads in the physical model of the prototype turbine.

C. METHODOLOGY

The distribution of unguided spring and summer river-run juvenile migrants at passage through the plane of the downstream bulkhead slot and at entry to the turbine's wicket gates will be determined using established hydroacoustic methods and instrumentation. Beads will be released in the physical model of the prototype turbine in the plane of the downstream bulkhead slot in a manner that simulates the distribution of river run juvenile migrants. Using high speed video cameras and image processing methods already demonstrated for this purpose, the distribution of beads at entry to the physical model's wicket gates will be observed. The distributions of beads and river-run migrants at wicket gate entry will be used to test the hypothesis that the distributions are the same.

D. RELEVANCE TO THE BIOLOGICAL OPINION FOR THE OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM AND JUVENILE TRANSPORTATION PROGRAM

Hydrosystem Substrategy 1.1; Key Alternatives Under Development – Turbine survival improvements for John Day Dam; Powerhouse Improvements for Ice Harbor Dam; Project Configuration RM&E – Turbine Studies; Hydrosystem Studies on Turbine Survival

III. PROJECT DESCRIPTION

A. BACKGROUND

1. Problem Description
   A goal of the Turbine Survival Program is to optimize the design and operation of turbines within the FCRPS for safer passage of juvenile salmonid migrants. The strategy to achieve this goal, Biological Index Testing, is based on the assumption that physical turbine models can be used to evaluate the turbine environment for fish passage and identify structural (design) alternatives and operations that will improve the safety of turbines for fish passage. Because the turbine environment is not uniform, the conditions fish experience during passage is a function of their elevation at passage through a turbine's wicket gates. While it is a relatively straight forward process to use beads in a physical model to estimate the elevation of beads at wicket gate entry, it is not clear that these estimates are an accurate

simulation of the entry of live fish, which may "behave" differently from beads during passage through a turbine intake and approach to a turbine's wicket gates.

2. Literature Review
   In process
3. Relationship of proposed research to other ongoing or proposed research.
   At this time there are no known conflicts or impacts on any other ongoing or proposed research. The physical model component of the study will be constrained in its schedule by other physical turbine model work which utilizes the equipment and manpower required to perform the work.

B. OBJECTIVES

See section II.

C. METHODOLOGY

1. Tasks
   Task 1: In consultation with the Turbine Survival Team identify a dam project and turbine that satisfies the following criteria:
   - A turbine unit that will be dewatered and available for installation of hydroacoustic instruments during the winter of FY07.
   - A turbine unit that is scheduled for continuous operation through the spring and summer juvenile outmigration periods.
   - A physical model for the turbine exists.
   - It would also be good if the selected turbine belongs to a turbine family for which fish passage studies have been conducted previously.

   Task 2: Installation of hydroacoustic instruments
   - There are two locations where observations of the distribution of spring and summer juvenile migrants are needed. One is in the plane of the downstream bulkhead gate slot in all three sections of a turbine intake. The second is at wicket gates that form the circular turbine distributor within the turbine scroll case.
   - Split beam transducers will be deployed from the surface on a modified acoustic scintillation frame or similar mounting fixture. The transducers will be aimed to permit detection, tracking, and estimation of the trajectory and elevation of unguided juvenile fish passing through the turbine intake.
   - A mixture of split-beam and single beam transducers will be placed in the turbine scroll case aimed to permit detection, tracking, and estimation of the elevation of unguided juvenile fish entering into wicket gate openings. The most likely wicket gate of passage will also be estimated.

   Task 3: Processing and analysis of juvenile fish echo records.
   - Hydroacoustic juvenile fish echo returns will be processed using current echo tracking technology.
   - Data resulting from processing of fish echoes obtained from hydroacoustic instruments mounted in the bulkhead gate slots of all intake sections will be analyzed to estimate the vertical distribution of unguided juvenile spring and summer migrants passing through the plane of the downstream bulkhead gate slot. Distribution estimates will be factored

by time of day and day within season with factoring limited only by sample size considerations.

- Data resulting from processing of echo returns obtained from hydroacoustic instruments mounted in the turbine spiral case will be analyzed to estimate the likely wicket gate of passage and the elevation of detected fish immediately prior to wicket gate passage.

Task 4: Report of findings of hydroacoustic sampling.

- A report describing the approach, methods, and results of hydroacoustic sampling in the test turbine intake bays and scroll case will be completed at the conclusion of this segment of the project. Since hydroacoustic sampling is scheduled to be complete in one outmigration season and the information gained through this effort is required for subsequent tasks, a report presenting findings is appropriate and needed.

Task 5: Acquisition of data using a physical turbine model for gate opening and elevation of entry of beads into the model turbines distributor given bead releases in the turbine intake that simulates the vertical distribution of fish observed using hydroacoustics.

- The experimental design for physical model observations will have to consider the operations under which hydroacoustic observations of fish distribution were obtained.
- It is also likely that more than one release distribution may be required to account for seasonal and other changes in the vertical distribution of river-run fish passing through the test turbine's intake.

Task 6: Test of the hypothesis that the pattern of entry of river-run juvenile fish to the test turbine's distributor and that observed for beads in a turbine physical model are the same.

Task 7: Project draft and final reports.

2. Limitations of proposed methodology and expected difficulties.
   - The availability of hydroacoustic instrumentation will depend upon the number of projects requiring the use of the same instruments and the priority of those projects. It is assumed that the required hydroacoustic instrumentation would come from the CE pool of such instruments. At this time the demands on available instruments is not known. Uncertainty in the availability and condition of hydroacoustic instrumentation represents the most serious risk for scheduling of this project.
   - Installation of hydroacoustic instruments within the scroll case of a turbine has only been accomplished once previously (Carlson, et. al. 2001). However, this work demonstrated the feasibility of installing acoustic devices within a turbine scroll case and maintaining them in operable condition for extended periods of time. The number of instruments that will be required to perform this study will be greater than that installed previously but the same methods for placing and securing hydroacoustic transducers and cables within the turbine environment so that they do not pose a risk to fish should be applicable in this case.
   - The methods used for acquisition of bead observations in a physical turbine model are well developed and no risk is apparent for this element of the project.
3. Expected results and applicability
   - The most important result is a test of hypothesis that addresses the scope of use of physical turbine models for implementation of BIT within the FCRPS.
4. Schedule
   - Acquisition of hydroacoustic instruments, replacement (in the case of cables), repair, and calibration – October 2006 – March 2007

- Installation of hydroacoustic equipments – March-April 2007
- Acquisition of hydroacoustic observations – April – July 2007
- Processing of live fish echo records – August – November 2007
- Presentation of results at AFEP annual review – November 2007
- Hydroacoustic sampling draft report preparation – November-December 2007
- Completion of final report – March 2007
- Acquisition of turbine physical model bead data – to be determined
  Project completion report – to be determined

D. FACILITIES AND EQUIPMENT

1. Requirements
   - A sufficient number of hydroacoustic instruments will be required to sample the three intakes of the test turbine and the circumference of the turbine's distributor. At this time it is assumed that the necessary instruments, with the possible exception of cable will be available from the CE inventory of hydroacoustic instruments. Cables, if required are a long-lead time item and will have to be procured immediately following project start up to avoid delays in initiation of sampling.
2. Justification for special or expensive equipment or services
   - Until otherwise evident, it is assumed that installation of hydroacoustic instruments will be made in a turbine that has been dewatered for other purposes and otherwise qualifies and is available for the use described in this proposal. PNNL would require some services from the dam project to secure access to the test turbine.
   - Special concrete bolts and installation tools may be required to secure hydroacoustic cables to the walls and floor of the test turbine scroll case.
   - It is possible that the test turbine cannot be dewatered for a considerable time following the study period for recovery of hydroacoustic transducers and cables. Previous experience has shown that the transducers themselves will probably withstand a long period of submergence in an operating turbine but the cables will not. It is very likely that the cables and some or all of the transducers deployed in the turbine will not be recovered or will be recovered in a badly damaged and inoperable condition and may not be repairable.

E. IMPACTS

1. Other ongoing or proposed research
   - The proposed project may compete for limited hydroacoustic instrument resources with other proposed or ongoing projects.
2. Projects
   a. Pre-season installation of equipment or other assistance
   - Installation of hydroacoustic instruments in-turbine can only be made when the turbine is dewatered. Therefore a dewatered turbine is required for installation and assistance from the project would be required for access to the dewatered turbine. At the present time it is unknown whether a dewater turbine will be available for this project.

   b. Special assistance or operation during the research

- The operation of the test turbine will need to be recorded. It is assumed that the standard methods used to document turbine operations will be sufficient for the purposes of this project. Access to turbine operations records will be required.

c. Detailed special operations

- No special operations have been identified at this time.

3. Biological Effects.
   - This project will not require the capture or handling of live fish. No impacts on river-run fish are expected.

F. COLLABORATIVE ARRANGEMENTS AND/OR SUB-CONTRACTS

- The project is a collaborative effort between PNNL and USACE ERDC.
- A sub-contract for one over review of statistical methods used for identification of metrics, sample size estimation, tests of hypotheses, and other statistical considerations will be required.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Partial list below, still in development:

Thomas J. Carlson and Gene R. Ploskey – Installation, and operation of hydroacoustic instrumentation, acquisition, processing, and analysis of hydroacoustic data, reporting.

David A. Davidson – Conduct of bead studies in selected physical turbine model, acquisition, processing, and analysis of bead observations, reporting.

John Skalski – Statistical consultant. – Experimental design, data analysis, and hypothesis testing assistance.

V. TECHNOLOGY TRANSFER

- The management use of the information provided by this project is to aid decision making for optimization of turbine operations at John Day and Ice Harbor dams to improve the survival of juvenile salmonids passing through turbines.

VI. LIST OF REFERENCES

Carlson, et. al. 2001, Ultrasonic 3-D Tracking of Fish and Drogues Passing Through a Kaplan Turbine Intake. Report to the US Army Corps of Engineers, WallaWalla District, April, 2001.

VII. BUDGET

Budget will be provided under a separate cover.